REMR Technical Note OM-MS-1.2
(Supersedes OM-MS-1.2 1991)

REMR Management System for Concrete Navigation Lock Monoliths

Purpose

This technical note provides information about the REMR Management System for concrete navigation lock monoliths.

Background

The U.S. Army Corps of Engineers operates approximately 270 navigation lock chambers constructed of plain or reinforced concrete. Many of these structures require, or will require, significant repairs to ensure safe and efficient operations. A quantitative rating system for the condition of concrete in navigation lock monoliths has been developed and is described in Technical Report REMR-OM-4 (Bullock 1989). This rating system provides a quantitative means for comparing the condition of concrete in one monolith to that in another. A computer application, LOCKWALL, employs this condition rating system and combines it with other procedures to provide a decision support tool to managers who plan REMR activities for concrete navigation lock walls.

REMR Management Systems

Modern engineering technology is providing procedures for performing condition surveys, consistent and quantitative condition assessment, and database management. Combined with economic analyses, these procedures allow efficient maintenance and rehabilitation (M&R) budget planning through the evaluation of current condition and the comparison of various M&R alternatives based on life-cycle costs. Collectively, these procedures are called REMR Management Systems (see REMR Technical Note OM-MS-1.1). Use of the REMR Management Systems removes many of the subjective elements in the decision-making process from M&R planning. LOCKWALL is a component system of the REMR Management System for navigation lock structures. Other components of the system address the REMR aspects of the miter gate and steel sheet-pile elements of lock structures. The LOCKWALL program addresses the REMR aspects of concrete navigation lock monoliths.

The LOCKWALL Program

LOCKWALL is a microcomputer-based application. As in most database-oriented programs, LOCKWALL performs database administration and calculations and generates reports. The following fundamental pieces of LOCKWALL are described: user interface, inventory, condition assessment, M&R alternatives, and life-cycle costs. For a complete description of the LOCKWALL program, see McKay and Kao (1990).

a. *User interface.* The LOCKWALL program runs in an IBM-AT compatible DOS environment and requires 640K free RAM. The user interface is menu driven, allowing even novice personal computer (PC) users to use the program easily. Condition assessment data are entered into the program just as it was entered into the inspection form in the field. The user "fills in the blanks" or checks the appropriate response when prompted by the program.

b. *Inventory.* The LOCKWALL program houses an inventory of all waterway systems and navigation lock structures contained within any given Division. Data pertinent to each structure, such as owner/operator, construction date, lock width, lock length, lock lift, etc., are stored. These data are in place when LOCKWALL is initially started. The first time condition-inspection data are entered for a given structure, LOCKWALL prompts the user to characterize each lock wall and guide wall by providing lists of the monolith identification (ID) numbers that comprise each wall. The monolith ID numbers are taken from engineering drawings. This one-time process ensures that monolith ID numbers used by different inspection teams remain consistent.

c. *Condition assessment.* The condition inspection data are gathered by visual observation and performance of simple measurements. The inspection catalogs the location and extent of concrete cracking, loss of volume, and deterioration. Other forms of distress such as exposed steel, leaks, stains, deposits, and missing or damaged armor are noted. The data are accepted and stored by LOCKWALL, which uses an algorithm (Bullock 1989) to produce a condition index (CI) for each monolith inspected. The CI is a numeric representation of the condition of the concrete in each monolith. The CI ranges from 0 to 100 with 100 reflecting an "as-built" condition. A CI under 40 indicates a "poor" condition. The CI algorithm is designed to produce CIs that reflect those conditions shown in Figure 1. Engineering and management actions associated with the CI are described in the same figure. Great care is taken in the development of the algorithm and inspection procedure to ensure that the results are consistent and repeatable. It is such uniformity that allows an objective comparison of the condition of concrete in one structure to that of another.

REMR Condition Index Scale

Zone	Condition Index	Condition Description	Recommended Action
1	85 to 100	**Excellent**: No noticeable defects. Some aging or wear may be visible.	Immediate action is not required.
	70 to 84	**Good**: Only minor deterioration or defects are evident.	
2	55 to 69	**Fair**: Some deterioration or defects are evident, but function is not significantly affected.	Economic analysis of repair alternatives is recommended to determine appropriate action.
	40 to 54	**Marginal**: Moderate deterioration. Function is still adequate.	
3	25 to 39	**Poor**: Serious deterioration in at least some portions of the structure. Function is inadequate.	Detailed evaluation is required to determine the need for repair, rehabilitation, or reconstruction. Safety evaluation is recommended.
	10 to 24	**Very Poor**: Extensive deterioration. Barely functional.	
	0 to 9	**Failed**: No longer functions. General failure or complete failure of a major structural component.	

Figure 1. REMR CI scale

d. *M&R alternatives.* A wealth of information regarding M&R operations for concrete lock walls has been gathered and stored in the LOCKWALL program. Most of the information is taken directly from EM 1110-2-2202 (Headquarters, U.S. Army Corps of Engineers 1986). The information exists in the form of American Standard Code for Information Interchange (ASCII) files. These ASCII files can be sent to the PC monitor for viewing or to the printer for hard copy. These files do not interact with the CI database in any way. They are strictly for information, to help the user research and determine proper maintenance strategies for a given set of distresses.

e. *Life-cycle costs.* The LOCKWALL program has a life-cycle costs analysis (LCCA) utility that can be directly tied into the CI inspection database. In terms of LCCA maintenance planning, all LCCAs require a standard input: inflation rate, interest rate, required life of overall maintenance plan, beginning year of maintenance plan, individual maintenance activity description, costs of individual maintenance activity, expected life of individual maintenance activity, and beginning year of individual maintenance activity. The standard

output is a financial schedule showing the required dollars and present worth of such dollars to implement each individual maintenance activity. Total cost and total present worth for the overall plan are also presented.

Future Developments

The collection of consistent, uniform condition assessment data will allow the generation of typical curves reflecting rates of deterioration. The combination of historical condition data and expert opinion should allow prediction of changes in the CI based on maintenance history, operating conditions, and applied M&R policies.

References

Bullock, R.E. (1989). "A Rating System for the Concrete in Navigation Lock Monoliths," Technical Report REMR-OM-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Headquarters, U.S. Army Corps of Engineers. (1986). "Engineering and Design: Evaluaiton and Repair of Concrete Structures," Engineer Manual 1110-2-2202, Washington, D.C.

McKay, D.T., and Kao, A.M. (1990). "LOCKWALL: A Microcomputer-Based Maintenance and Repair Management System for Concrete Navigation Lock Monoliths," Technical Report REMR-OM-10, U.S. Army Construction Engineering Research Laboratories, Champaign, IL.